



Keys to the Rainbow

(How will we detect life around other stars?)

Discover how we learn about stars and the atmospheres of exoplanets by examining the light in greater detail. Match up the spectra of stars and planets with their atmospheric ingredients. In particular, what ingredients are we looking for in planets that may harbor life?



Topics Covered:

- How we spread light out to glean more information about its source
- What's in stellar atmospheres
- What kinds of ingredients we are looking for in the atmospheres of potentially habitable planets

Participants:

This activity works best with a group of 10 or fewer participants so that many people get Ingredient Transparencies. Ages 7 to adult will enjoy this activity at different levels.

Location and Timing:

This activity can be used before star parties, indoors or out, with scout troops and with youth groups. It works best with groups of 10 or fewer. It can run 10 to 15 minutes. To use with a larger group, access the slides on the "Anyone Out There?" PowerPoint, found here:

<http://nightsky.jpl.nasa.gov/download-search.cfm>

Materials Needed:

- Keys to the Rainbow Background Sheet
- 9 Transparencies of one Star, two Planets, and 9 Ingredients
- Box or box-top measuring 8.5" by 11" to hold the sheets
- (Optional) Stress ball with planet and "gravi-tee". See Materials and Set Up.

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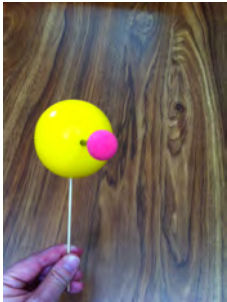
Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>



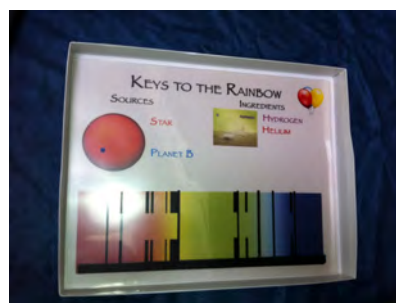
Detailed Activity Description

Keys to the Rainbow

Leader's Role	Participants' Role (Anticipated)
<p>Presentation Tip: Notice that when this activity is presented to a general audience, we don't use words like spectrum, spectral lines, or emission. This is simply a fun matching game to give the layperson an idea of how we get information from light. If presenting to a more advanced audience, feel free to introduce more complex ideas.</p>	
<p><u>To Do:</u> Have the box ready with the Rainbow sheet showing. Keep the planet transparencies and the star transparency to the side. Have the diffraction gratings ready.</p> <p><u>To Say:</u> When we look up at night, what do you see? Do you think any of these stars have planets around them? Does our star have planets around it? How many of the Sun's planets do we know of that have life? How do you think we can find out if any planets around other stars have life too?</p> <p>Right. But even through our very biggest telescopes, all we see from a star is a point of light. The stars are so far away, we can't measure how wide one is or even see that they're round. So how do we learn about stars when all we ever see are points of light? The secret is what's hidden in that light.</p> <p>What may look like white light to our eyes is actually made up of many different colors. Does anyone know what we see when white light goes into a prism?</p> <p>Scientists spread out the light in this way to learn more about stars. Let me show you how. White light will show the full rainbow of colors. But when we take a closer look at the light of a star like our Sun, it looks like this.</p> <p><u>To Do:</u> Place the star transparency on the rainbow.</p>	<p>Stars! Yes Yes Just Earth</p> <p>Telescopes!</p> <p>A rainbow</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> What do you notice?</p> <p>That's right. What do you think is causing these lines?</p> <p>It's actually because the white light coming from the star must first pass through the star's atmosphere. That's right, stars have atmosphere too! The ingredients in a star's atmosphere block very narrow areas of color in the rainbow. Each ingredient has its own unique set of lines. This tells us what's in the atmosphere of the star. So these lines represent a combination of many ingredients together. Here, who wants to take an ingredient and see if its lines are in the in the spectrum?</p> <p><u>To Do:</u> Hand out the 6 ingredients to your visitors. Allow them to "test" whether their lines are in the stellar rainbow. That is, match the lines from the star's atmosphere.</p> <p><u>To Say:</u> Great! So hydrogen and helium are present in the star's spectrum but these others are not. We can tell a lot about what the star is made of by spreading out the light. But that's not all! Sometimes the planets orbiting a star will pass in front of the star, blocking a bit of the light and giving us valuable information. This can be especially useful if the planet has an atmosphere. Does our planet have an atmosphere?</p> <p><u>To Do:</u> Demonstrate a planet passing in front of a star to your visitors using a yellow stress ball "star" with an orbiting planet.</p> 	<p>Lines!</p> <p>Sunspots?</p> <p>Hydrogen, helium are both in the atmosphere</p> <p>Yes!</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> Let's say this planet has an atmosphere, like Earth does. The light from the star also passes through the atmosphere of the planet. While that planet passes in front of the star, we get information about its atmosphere, and this can tell us a lot about the planet. Let's see what's in this planet's atmosphere. We'll leave the hydrogen and helium up since those lines come from the star, not the planet.</p> <p><u>To Do:</u> Place Planet A on top of the star and invite your visitors to see if their ingredients match the planet's lines.</p> <p><u>To Say:</u> So this planet has carbon dioxide in its atmosphere. Unfortunately, that's not a promising indicator for life, and we're looking for a planet that could support alien life. What we'd like to find is water in the atmosphere!</p> <p><u>To Do:</u> Give back the ingredients and place Planet A aside. Then place Planet B on top of the star, hydrogen, and helium transparencies.</p> <p><u>To Say:</u> What if we saw THIS planet passing in front of a star? Who has an ingredient in this planet's atmosphere?</p> <p>This planet has water in its atmosphere! That's a good indication we want to look here for possible life.</p> <p>We're hoping to find a planet with water in the atmosphere someday. Oxygen, methane, and ozone would also be good indicators that we should examine a planet for life. All of those ingredients disappear out of the atmosphere fairly quickly unless something is constantly producing them. These would be excellent places to look for possible alien civilizations!</p>	<p>Carbon dioxide</p> <p>Water, oxygen, ozone</p>



Extensions to the Keys to The Rainbow

Show how we use **redshift** and **blueshift** to tell whether a star is coming toward us or going away. Place the hydrogen and helium lines on the rainbow background. Then place the star transparency on the full rainbow. With your face on the right side, move the top transparency away from you, showing how the lines shift to the red part of the spectrum when a star is moving away. (Note that this model is not exactly accurate, since they do not shift uniformly.) This technique is used for more than stars. Find background information here:

http://www.esa.int/esaSC/SEM8AAR1VED_index_0.html

Or view this whimsical video here:

<http://www.spitzer.caltech.edu/video-audio/125-ask2006-001-What-Is-a-Redshift>

There is also further explanation behind the "wobble method" described in the *How Do We Find Planets?* activity. The tug on the star is "seen" as it wobbles toward and away from us by noticing the shifts in the spectral lines.

Materials

1. Print the Light Source and Ingredients transparencies on color transparencies, available at office supply stores. It is best to print these from an electronic source, and not simply make copies. Making copies can result in mis-alignment of the rainbows.
2. Foam balls, also called "stress balls." You may be able to find them at a local craft store, but generally, these can only be ordered in large quantities. Quantum Promotions will sell as few as 10 stress balls at once. They refer to these as "sample" shipments. For 10 stress balls, the quoted price as of February 2011 is \$2.23/ea, plus shipping. You can order them by any of these methods:
 - EMAIL: sales@quantumpromotions.com
 - Contact the sales rep, Steve Tallman, at: stallman@quantumpromotions.com
 - CALL toll free at: 1-877-776-6674
3. Golf Tees: golfing supply store
4. Attached planet: Glue a small rubber ball or marble with super glue to a golf tee. Using super glue is the most effective and secure method. You don't want the ball flying off the tee and hitting someone. Alternatively, you can wrap a small ball of clay around the end of the golf tee

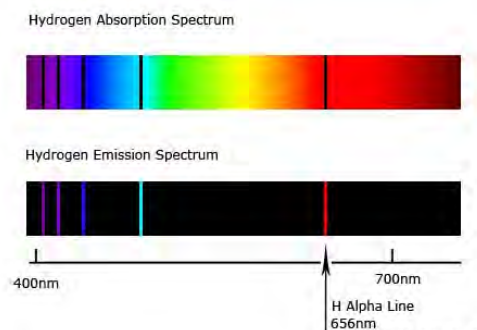


Background Information

Adapted from NASA's Imagine the Universe website:
http://imagine.gsfc.nasa.gov/docs/science/how_l1/spectra.html

The word 'spectrum' (the plural of which is 'spectra') comes from a Latin word, spectare, which means 'to make a display out of something.' In astronomy, we make a display of electromagnetic radiation, or light. In particular, we spread out radiation into tiny increments of energy in order to examine all of its pieces. On a big scale, we can think of the electromagnetic spectrum, which refers to all the different energies of radiation from the very lowest energy radio waves to the very highest energy gamma-rays. It is hard to examine the whole electromagnetic spectrum at once, so scientists often break it down into smaller regions for their studies. In this activity we are looking at the visible light spectrum.

Each element in the periodic table can appear in gaseous form and will produce a series of bright lines in the spectrum unique to that element. (right, lower) Hydrogen will not have the same lines as helium that will produce different lines than carbon... and so on. When white light passes through a cloud of hydrogen gas, you will see dark lines imposed on the full spectrum. (right, upper) Thus, astronomers can identify what kinds of ingredients are in stars' atmospheres from the lines they find in the star's spectrum. This type of study is called spectroscopy.



The science of spectroscopy is quite sophisticated. From spectral lines astronomers can determine not only the element, but also the temperature and density of that element in the star. The spectral line also can tell us about any magnetic field of the star. The width of the line can tell us how fast the material is moving. We can learn about winds in stars from this. If the lines shift back and forth we can learn that the star may be orbiting another star. We can estimate the mass and size of the star from this. If the lines grow and fade in strength we can learn about the physical changes in the star. Spectral information can also tell us about material around stars. This material may be falling onto the star from a doughnut-shaped disk around the star called an accretion disk. These disks often form around a neutron star or black hole. The light from the stuff between the stars allows astronomers to study the interstellar medium (ISM). This tells us what type of stuff fills the space between the stars. Space is not empty! There is lots of gas and dust between the stars. Spectroscopy is one of the fundamental tools that scientists use to study the Universe.

A much more detailed explanation by Dr. James Kahler can be found here:
<http://stars.astro.illinois.edu/sow/spectra.html>

For more on what's causing the spectral lines:
<http://www.avogadro.co.uk/light/bohr/spectra.htm>

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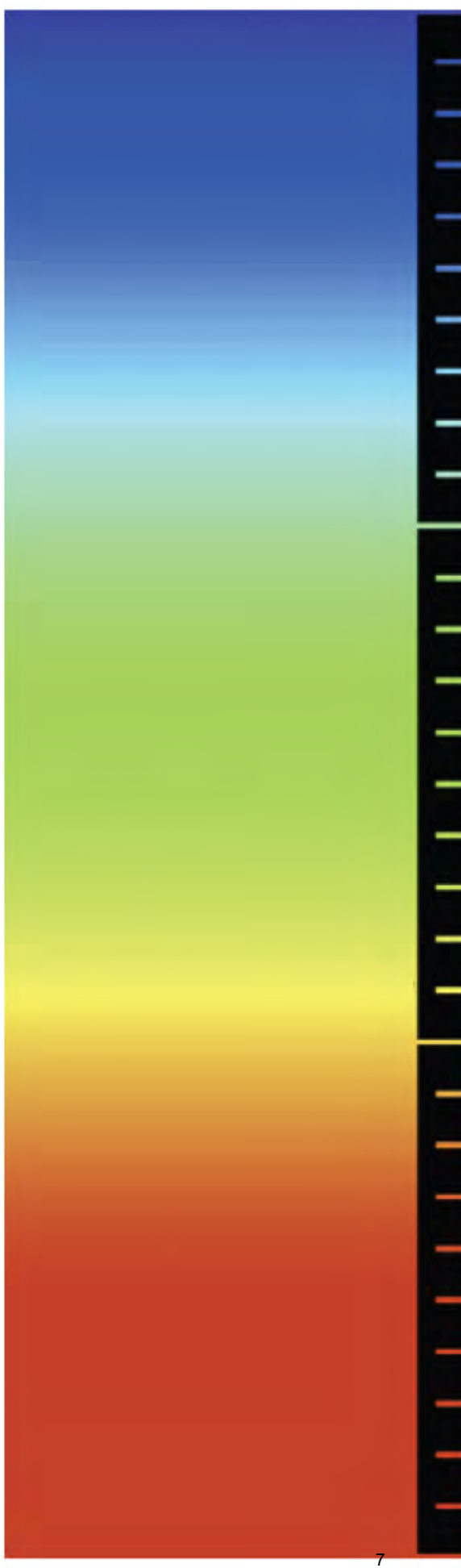
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KEYS TO THE RAINBOW

SOURCES

INGREDIENTS





STAR



• PLANET A

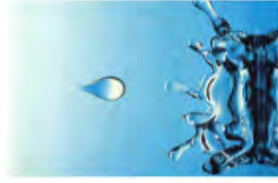




PLANET B

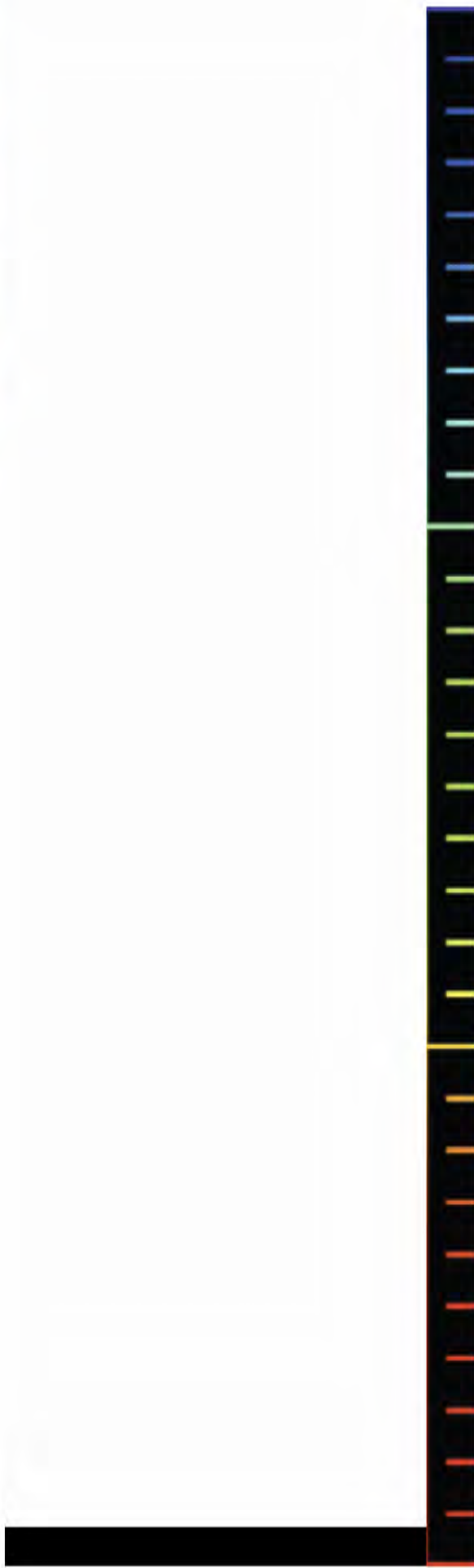


WATER



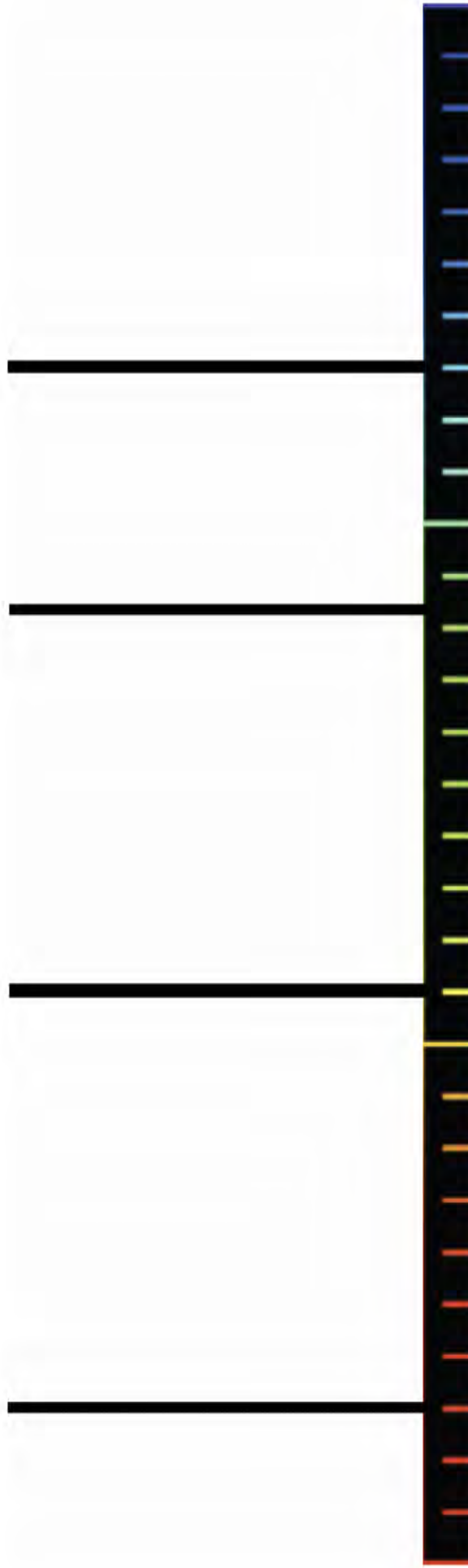


CARBON DIOXIDE



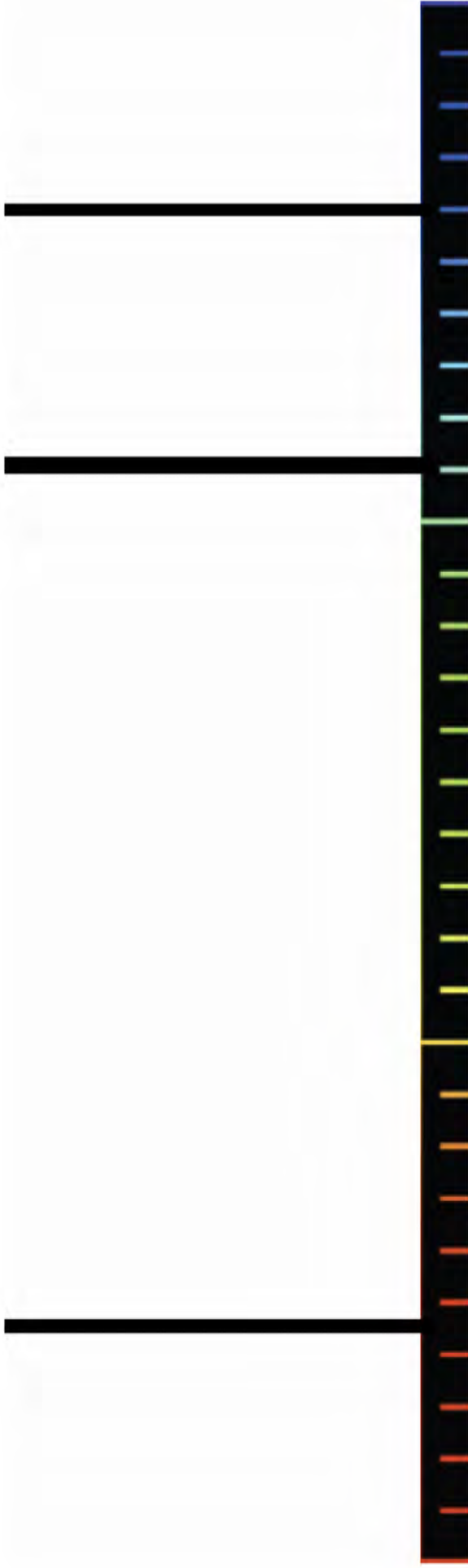


HELIUM

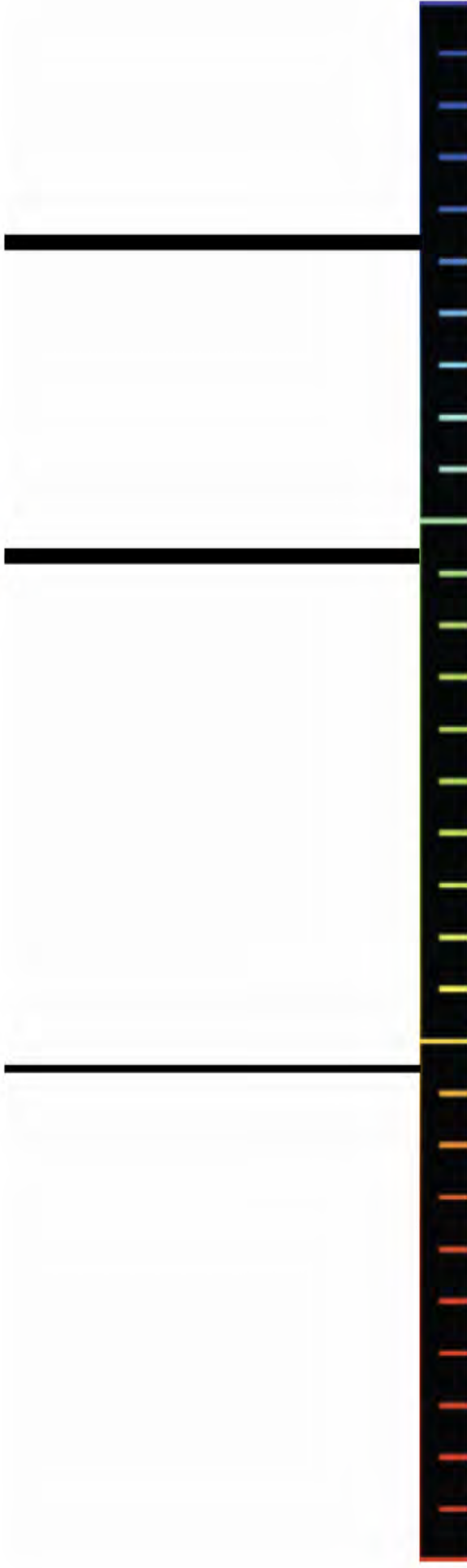




HYDROGEN



OXYGEN





OZONE

